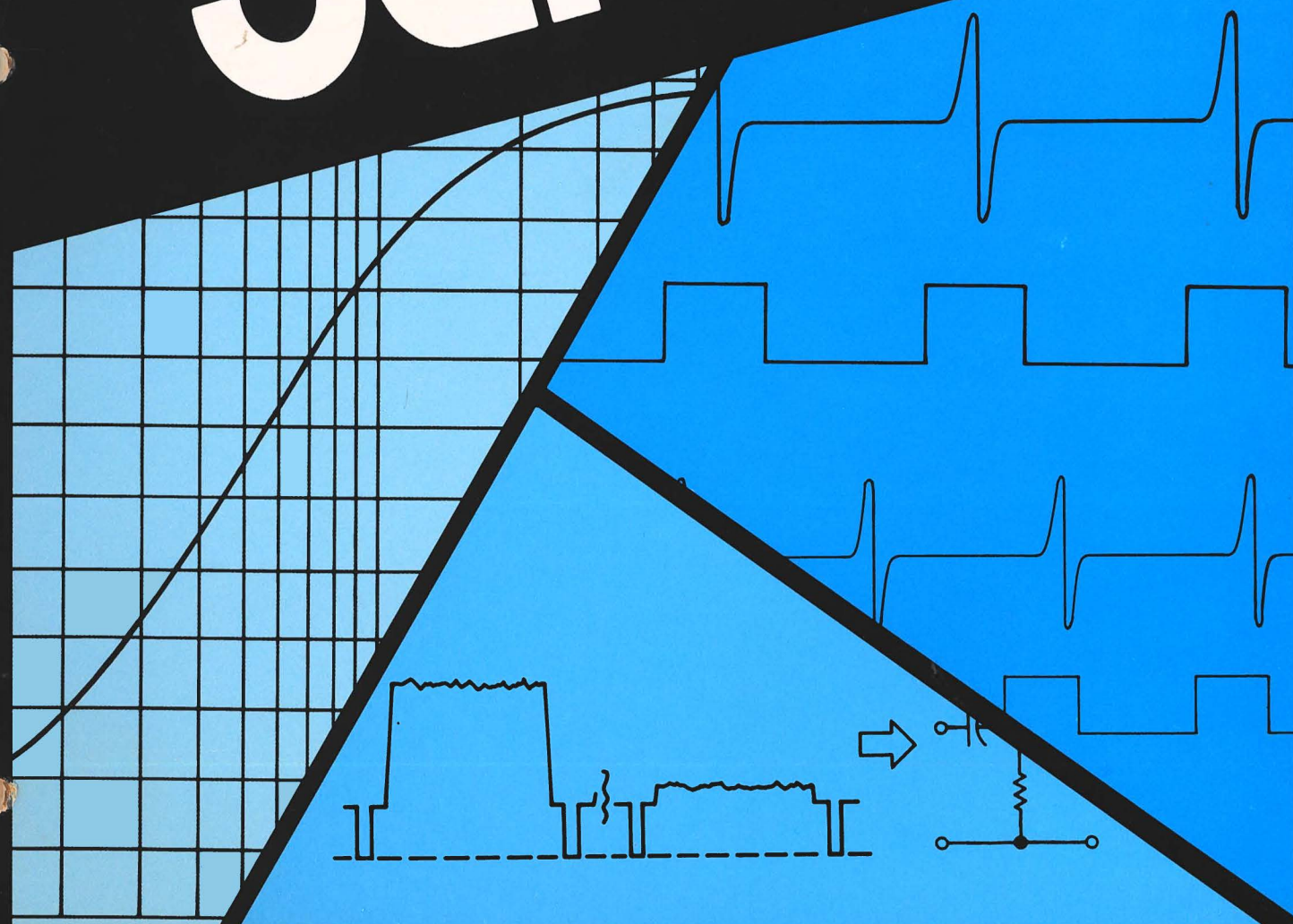


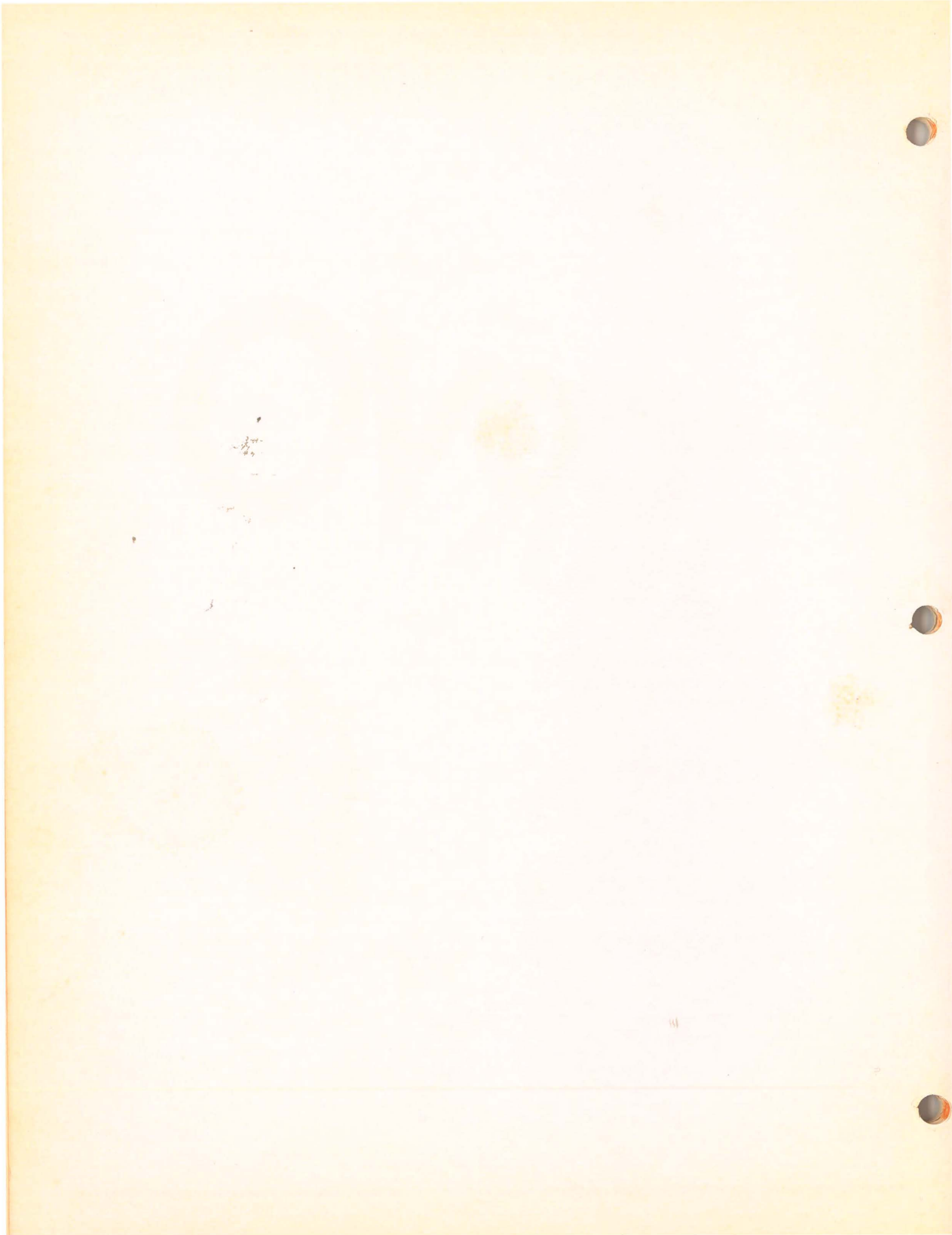
SONY BASIC VIDEO RECORDING COURSE
BOOKLET #6

SCANNER

SERVO

SYSTEMS





SONY®

BASIC VIDEO RECORDING COURSE

BOOKLET 6

SERVO SYSTEMS

Introduction

In this lesson you will study basic servo systems, and the circuits used to implement servo action. Actual systems will then be analyzed to transfer basic concepts into actual practice.

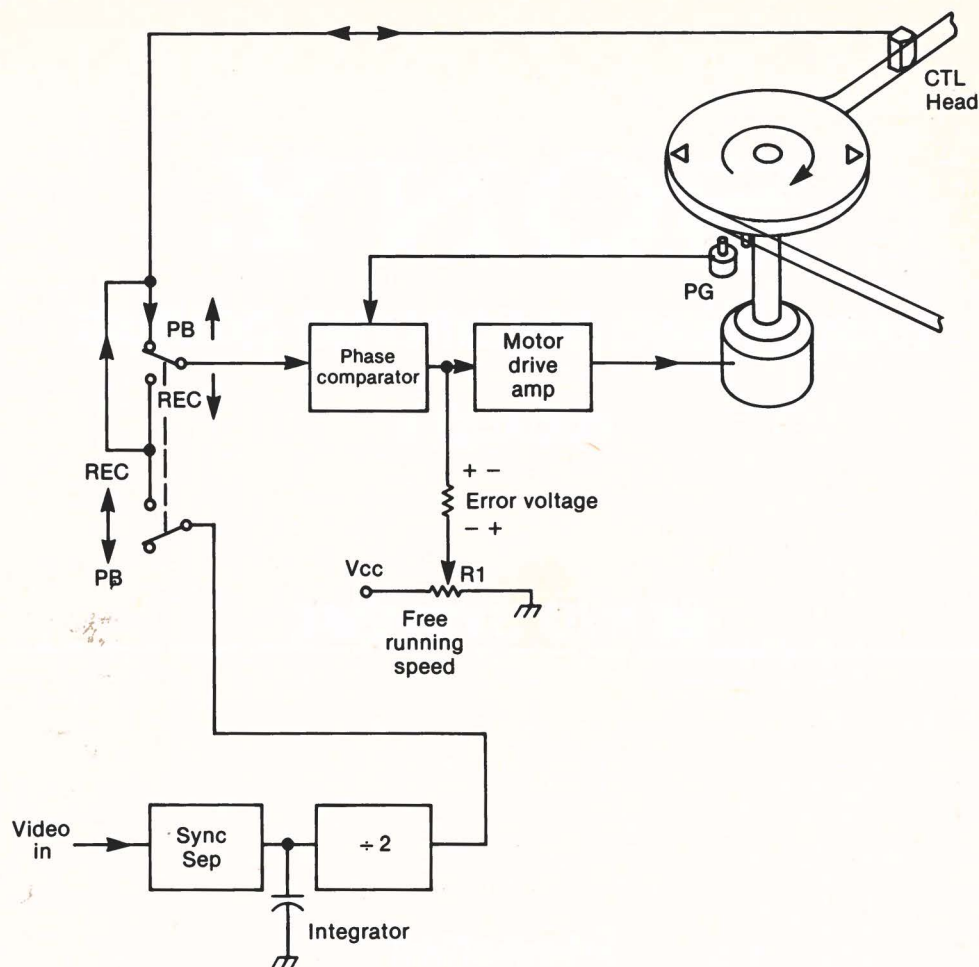


Fig. 1. Basic scanner servo.

1. BASIC SERVO SYSTEMS

Both scanner and capstan servo systems are fundamentally speed controllers that can be speeded up or slowed down to bring about desired timing or phase relations. An example of the latter is the position on the video track at which vertical sync is recorded. A simple analogy is an ordinary electric clock. When plugged into an outlet it turns at the correct speed, the second hand making one complete transit in 60 seconds. Relative timing, or phase, to coincide with local time is accomplished by moving the hands forward or back (speeding up or slowing down) until the noon reading coincides with the passage of the sun past the local meridian. In the same way, VTR servos are speed controllers that can be speeded up or slowed down to match the required phase relation between the video signal and the position of the video head along the track.

Fig. 1. shows a generalized basic block diagram of a scanner servo. In this example the rotational speed of the d-c servo motor that drives the scanner is set by R1. It is set for the correct free-running speed. A d-c error voltage, developed in the phase comparator, modifies the voltage at the arm of R1 to alter scanner speed. Thus, we have the means to effect the required phase relationships. In the record mode, correct phase occurs when the vertical sync pulse is recorded at a specified distance from the start of the track. This distance is determined by the location of the head-switching point and the amount of overlap.

The phase comparator compares two events when the machine is in the record mode: the arrival of vertical sync separated from the signal that is being recorded, with a feedback pulse produced by a pick-up coil in the scan-

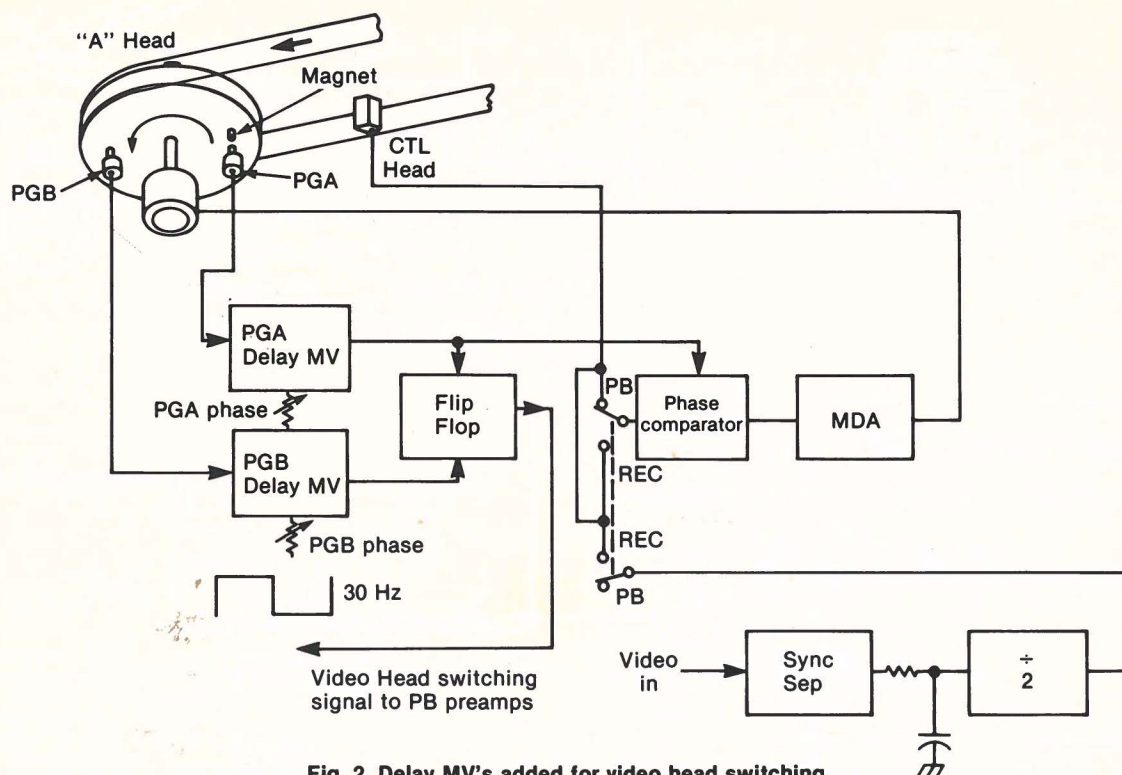


Fig. 2. Delay MV's added for video head switching.

ner. This pulse signals the arrival of the reference video head (video head A in Sony machines) at the point on the track where vertical sync is to be recorded. Early or late arrival of the video head at this designated point results in the production of a d-c error voltage whose polarity is such that it will speed up or slow down the scanner to effect the correct relative timing. The amplitude of this error voltage is proportional to the amount of timing (phase) error.

While the recording is in progress a square wave derived from separated vertical sync is recorded on the control track. Thus, at the instant the reference video head is recording vertical sync on the video track, the transition of the wave is recorded on the control track.

In playback the same transition of the control track signal serves as the timing reference for the servo system. Note that playback control-track signals are routed to the phase comparator in place of separated vertical sync when the REC-PB switch is set to playback. The pulse that appears at the output of the control track head when the square wave transition crosses the head gap signals the servo system that a prerecorded track is in place around the scanner, and the reference head

should be crossing the point on that track where vertical sync has been recorded.

The foregoing is a brief review of the basic action of the scanner servo system. Now we will add functional blocks gradually. The added blocks permit timing of various events to be trimmed electronically.

30 PG Delays. The pulse coil that generates the servo feedback pulse, called 30 PGA, is located in the scanner at a point where the pulse is generated somewhat early. That is, the pulse is generated before the A head gets to the point on the track where vertical sync is recorded. A variable delay multivibrator (MV) is then inserted into the signal path from the pulse coil to permit the timing of the 30 PGA pulse to be adjusted. See Fig. 2. The delay adjustment provides the same effect as advancing or retarding the mechanical position of the pulse coil.

A second pulse coil develops a pulse just before the B video head crosses the point at which vertical sync is recorded on the next field. This pulse normally plays no part in servo timing but is used in video head switching to start the interval in which the B head is on and the A head is off.

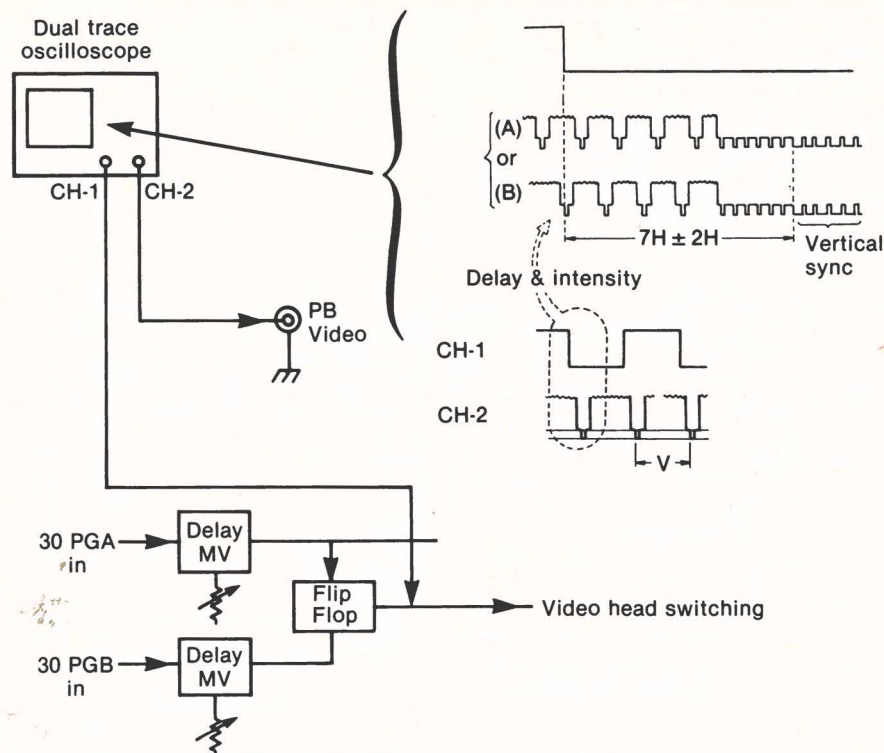


Fig. 3. Setup for adjusting the head-switching points.

A second delay multivibrator is in the feed path from the 30 PGB coil. Outputs from delay multivibrators for the 30 PGA and 30 PGB signal toggle a Flip Flop that produces the video-head switching signal. These square waves are routed to the playback preamps to turn on and off the A and B amplifying channels.

The potentiometer that controls the amount of delay inserted to the 30 PGA and PGB multivibrators are labelled PGA PHASE and are adjusted with the machine in the playback mode using the factory alignment tape as the signal source.

They are adjusted to place the head-switching transition at the required time interval ahead of vertical sync. Consider the logic of this for a moment. The factory alignment tape is recorded under vigorously controlled conditions, and you can be sure that vertical sync is recorded at precisely the correct point on the video track. Thus when this tape is played, servo phase is set to put the switching transient the specified interval before vertical sync in the playback signal. Fig. 3. shows the setup for adjusting PG phase. A dual trace scope is used to display playback video and the 30 Hz switching square wave simultaneously. The delays are

then set to put the transition the specified time interval ahead of vertical sync. (6.5 lines for U-matics, 7 for Betamax). A tolerance of ± 2 lines is usually applied. Separate adjustments are made for A and B phase. When the scope is triggered from the 30 Hz square wave, the start of either the A or B intervals can be selected by simply switching the polarity of the signal at the scope's trigger controls.

Lock Phase. The 30 PGA pulse is developed before the A head crosses the point in the scanner where head switching is to occur. See the detail in Fig. 4. And the PGA delays are set so that head switching occurs at the right point. Some 6 to 7 lines later vertical sync appears on the track. Since the timing comparator compares sync with the feedback pulse another delay must be added to the PGA signal to make it coincident with vertical sync. This delay is added by the lock-phase delay multivibrator shown in Fig. 4. This delay is adjusted in the record mode so that head switching occurs the same 6 or 7 lines before vertical sync in the signal to be recorded. When this adjustment is completed the machine lays down the video recording in the same way in which it is recorded on the alignment tape.

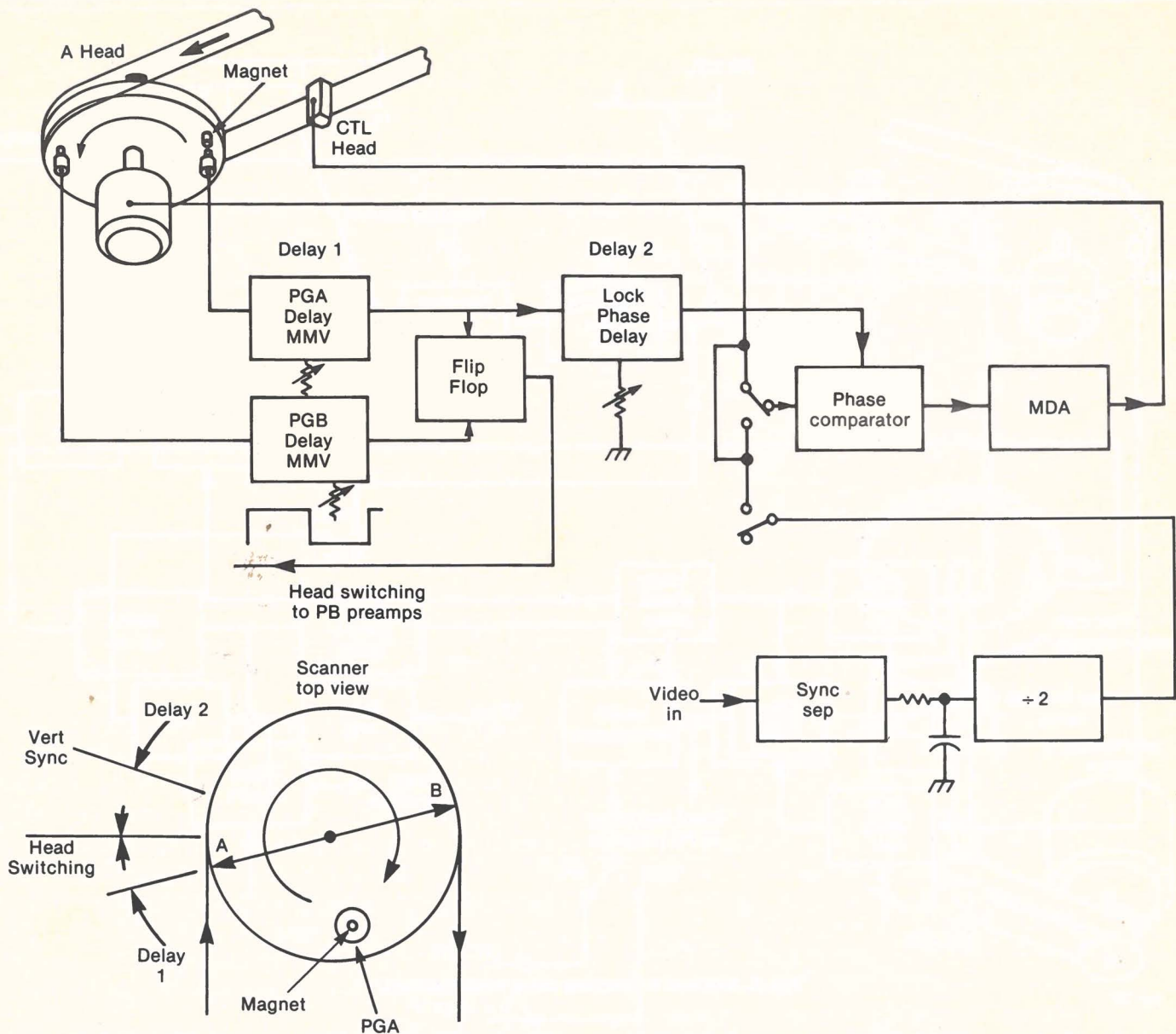


Fig. 4. Lock phase delay added.

In some systems the lock phase delay is fixed and a variable delay MV is placed in the sync feed to the phase comparator. A separate delay may also be used in the CTL feed. This method permits time trimming to compensate for differences in inherent delays introduced by the integrator in the sync separator.

Tracking Control. The timing of the playback control signal is determined by the distance between the scanner and the audio/control-track head stack, as measured along the tape path. During alignment of the machine the factory alignment tape is played back and the position of the audio/CTL head is adjusted to

produce maximum r-f output from the video heads. This occurs at optimum tracking where the heads are riding the centers of the pre-recorded video tracks. Provision is made in the mounting arrangement of the audio/CTL head stack to permit slight upstream-downstream adjustment of head stack location.

To permit the user to compensate for small tracking errors, because of slight mechanical differences between machines, a front-panel *Tracking control* is added. This control provides the electrical equivalent of moving the audio/CTL head stack along the tape path. Here again delay multivibrators do the time-trimming job.

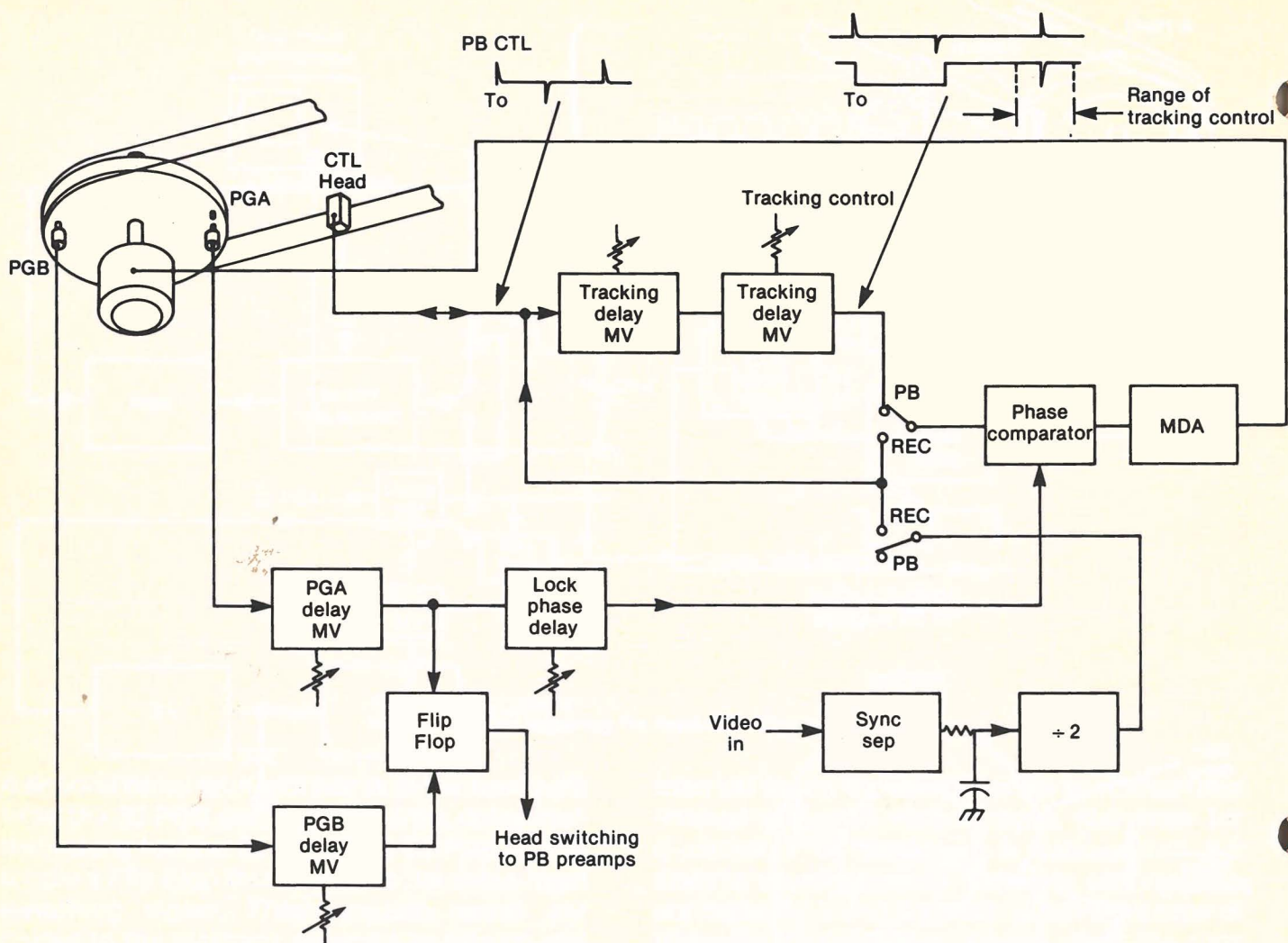


Fig. 5. Addition of tracking delay multivibrators.

A pair of delay multivibrators, connected in cascade, are inserted into the control-track pulse playback signal path as shown in Fig. 5. The first delay MV inserts a delay that is determined by a service adjustment. The delay added to the second MV is controlled by the front-panel Tracking control. When the latter is set to mid range, often a detented setting, the overall delay inserted by both MVs is equal to the time interval between control-track pulses. This interval is 1/30th of a second (1/29.97 seconds for color recordings). Under these conditions the servo is actually working from the control track signal for the previous frame in the recording. The control range of the second MV permits timing to be advanced or retarded to simulate upstream or downstream movement of the audio/CTL stack.

The basic block diagram of Fig. 1. has now grown to include the basic phase-adjusting blocks shown in Fig. 5.

Types of Servo Systems. A number of systems have been developed to implement the basic scanner servo shown in Fig. 5. But all are basically speed controllers with overriding control of phase. A system adopted early in helical scan recorders used a *braking principle*. Here speed is controlled by an a-c hysteresis motor that turns at precisely 30 rps and makes use of the accuracy of powerline frequency found in most advanced countries. The scanner is driven from the motor by a belt and pulley arrangement in which pulley ratios are designed to drive the scanner at a speed just above the design speed of 29.97 rps.

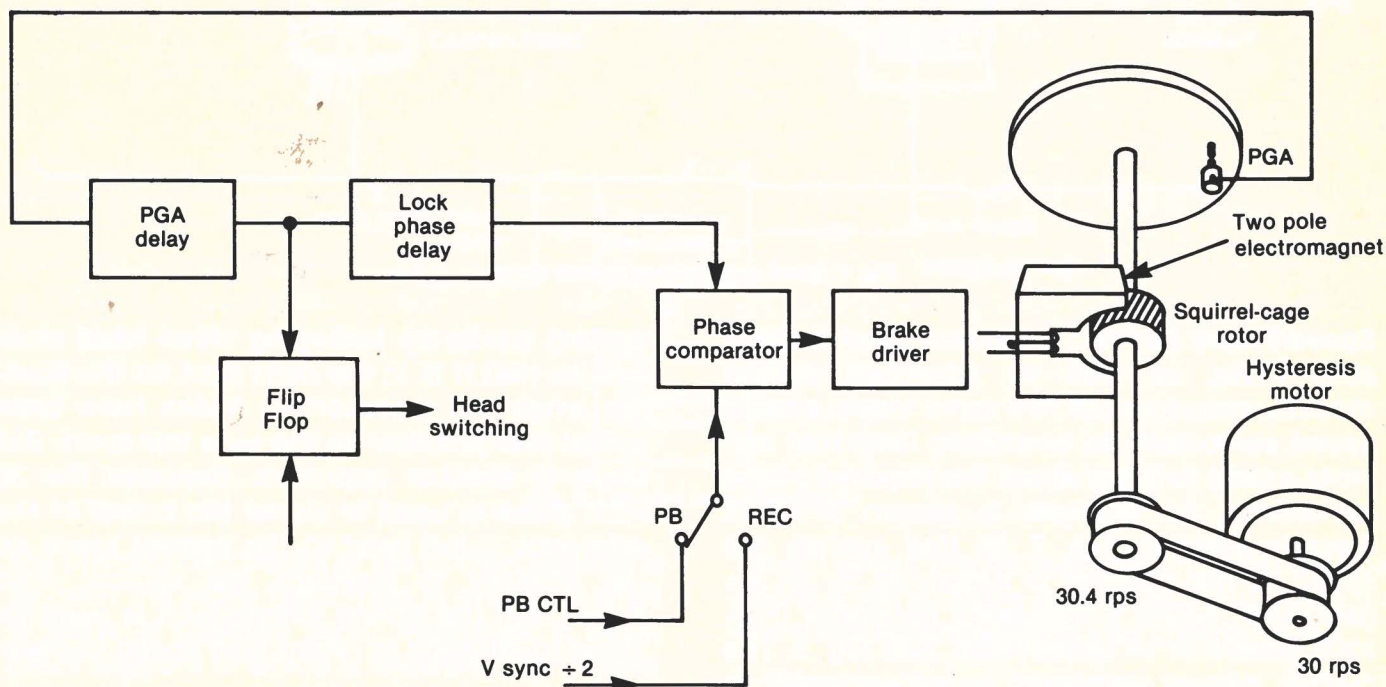


Fig. 6. Basic braking servo.

Typical values are in the range of 30.3 to 30.5 rps.

The phase comparator controls braking action by means of an electronic brake as shown in Fig. 6. The rotor is very much like the rotor of a squirrel cage a-c motor and is mounted on the shaft of the scanner. The rotor turns in the magnetic field of a two-pole electromagnet in which the direct current flowing in the field windings is amplified comparator error voltage. This system corrects phase once per revolution, an action that results in stabilization at the correct speed. Errors in phase result

in more or less braking action to retard or advance phase as needed.

Braking servos are extremely rugged and reliable as they make use of a-c hysteresis motors, which as you learned earlier, do not make use of commutators and brushes. The drive belt is subject to wear, but this is a relatively inexpensive replacement part. A minor disadvantage of braking systems is very close tolerances on a-c line frequency ($\pm 0.5\%$ or ± 0.3 Hz in 60-Hz systems). This practically rules out operation from portable sources of a-c power.

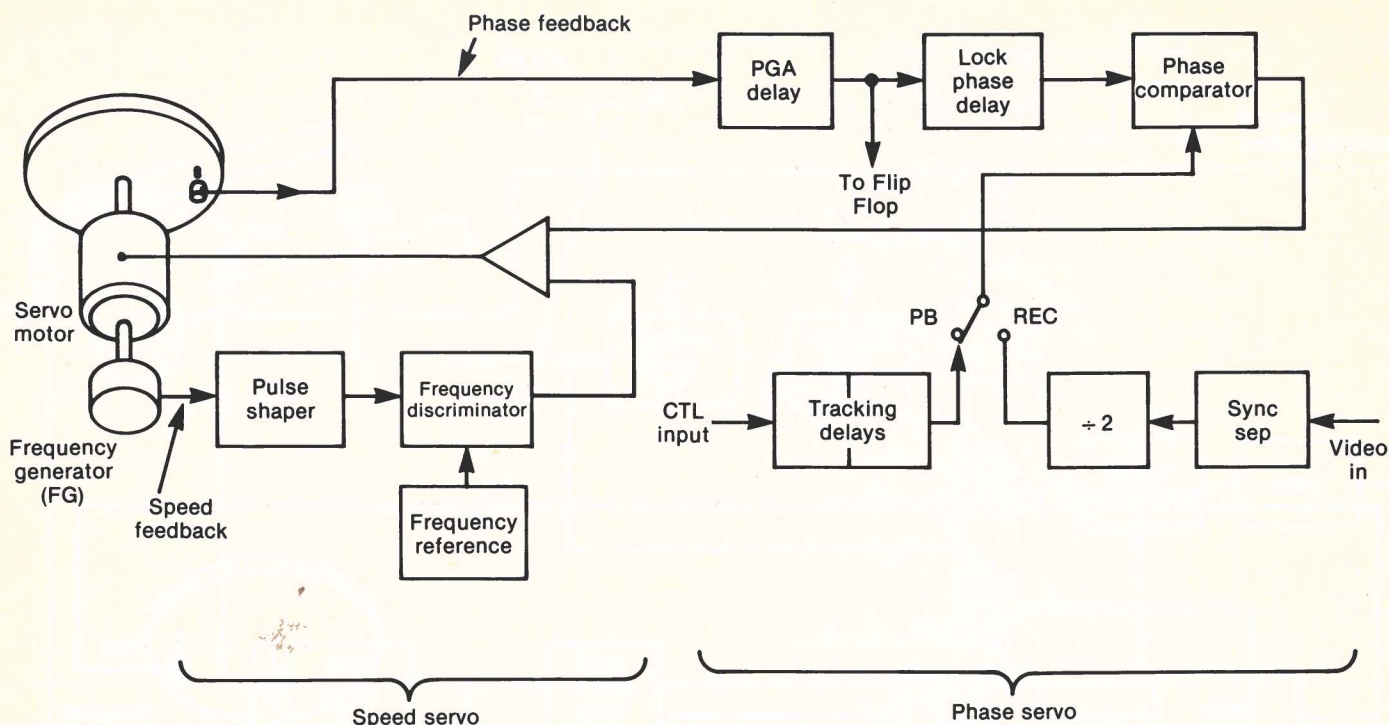


Fig. 7. Basic speed/phase scanner servo.

Speed/Phase Servos. A system used in portable VTRs, as well as advanced editing models, makes use of two servo loops: a basic speed servo with an overriding loop that corrects speed to bring about the required phase conditions. An example is shown in block diagram form in Fig. 7. In this system the speed of the scanner is measured by an a-c generator, called a frequency generator (FG), tone generator or tachometer. See Fig. 8. The signal, whose frequency is proportional to scanner speed, is compared with a frequency reference and the error voltage produced by this comparison determines motor speed. In actual systems the *period* of the frequency generator is compared against the period of some reference, such as that of a multivibrator, and resulting error voltage controls motor armature current. A second servo loop compares either separated sync (record) or control-track signals (PB) with the 30 PGA pulses to produce an error voltage proportional to phase error. This error voltage modifies the speed error voltage to achieve phase correction.

Capstan Servos. In the scanner servo systems discussed so far, the playback of the control track signal is the timing reference for getting the reference video head in place on time. The

system works by jockeying video head position so that it is in the right spot on the scanner when the prerecorded tracks have been pulled into position by the tape transport. But there is another approach. Suppose the 30 PGA pulse is used to signal the arrival of the reference video head at the correct place on the scanner to playback the vertical sync signal, but the timing comparison is used instead to advance or retard tape speed to place

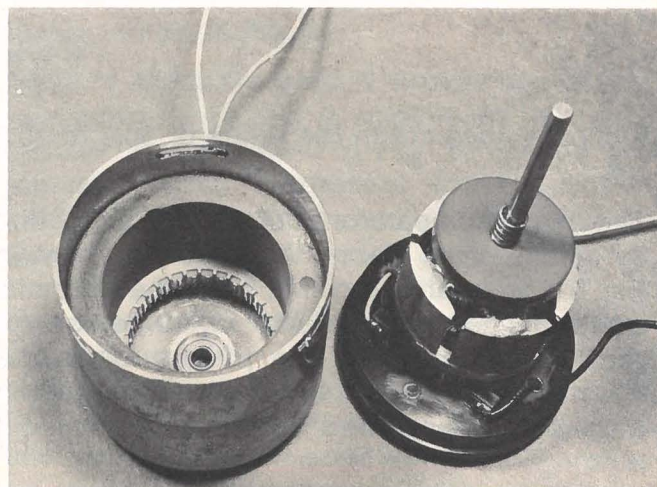


Fig. 8. Frequency generator consists of rotating PM field and multipole stationary armature.

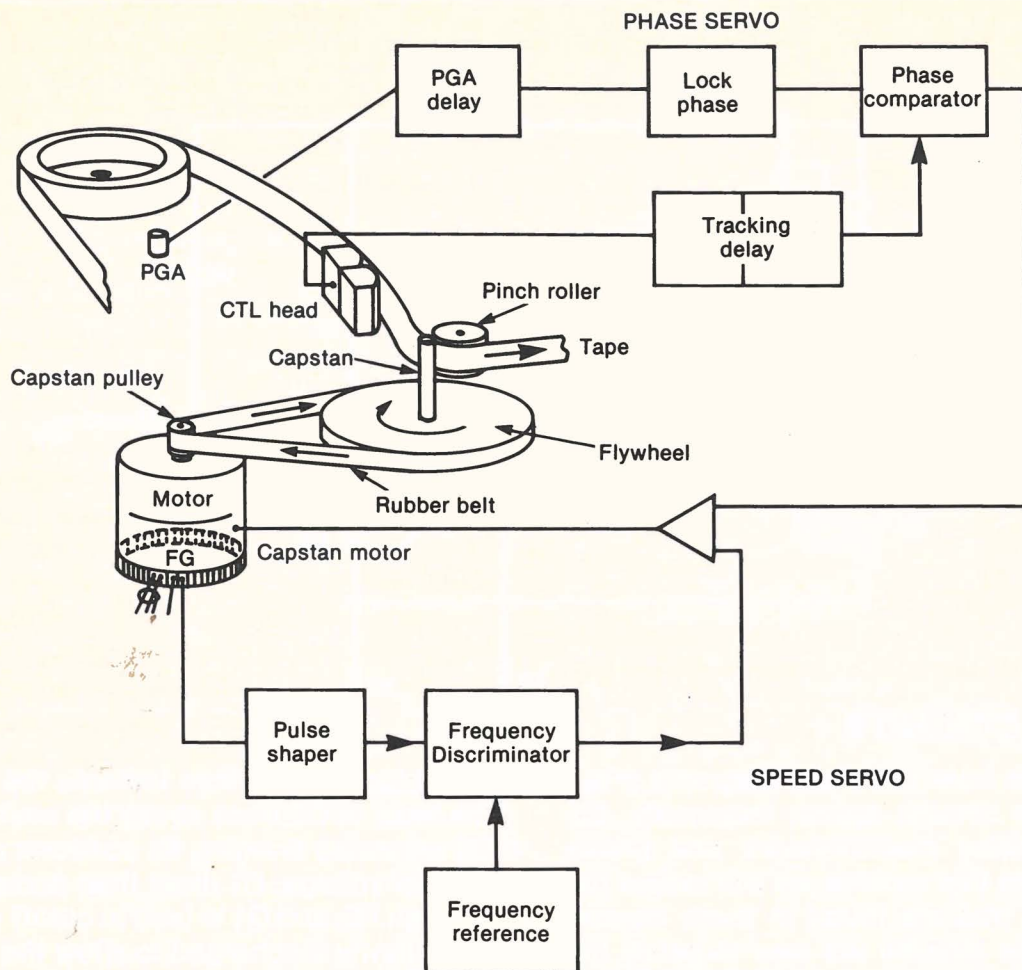


Fig. 9. Capstan servo (playback).

the prerecorded tracks at the correct positions to meet the video head. This is precisely what is done in capstan servo machines, a basic block diagram of which is shown in Fig. 9. Here the scanner is locked to some stable source of 30 Hz signals. The 30 PGA pulse signals the arrival of the reference head at the point on the scanner some 6 to 7 lines ahead of the place where vertical sync is recorded. This pulse is again compared with the CTL pulse in playback, but the error voltage is used to drive the capstan motor. Tape is now speeded up or slowed down so that the prerecorded track is accurately placed to meet the video head at the designated point on the scanner.

Capstan servos are prerequisite for editing VTRs. Here the scanner is always locked to incoming video in both the playback and record modes. In playback the capstan is driven by the servo that compares 30 PGA pulses with prerecorded control-track signals. In this way the machine can be switched from playback to

record within the vertical blanking interval. The scanner servo stays locked to input video so the transition is smooth and uninterrupted.

Editing machines have two modes for edit operations—*insert* and *assemble* editing. In the insert mode, when a short “cut” is inserted somewhere between the beginning and end of the program the scanner servo remains locked to input video, and the capstan servo remains in the playback mode, using previously recorded control track pulses. In the assemble mode, the scanner remains locked to input video, but the capstan servo switches over from control-track signals to become a simple speed controller in the record mode.

Capstan servos provide inherently better time-base stability because the scanner servo is always locked to a very stable source of timing signals. For this reason it is often found in machines that do not provide editing functions.

2. SERVO CIRCUITS

As you can see from the block diagrams given so far, certain circuits appear frequently. Examples are delay multivibrators and phase comparators. In this section we will review the basic circuits that are found in these blocks. Although these circuits are now largely implemented by dedicated integrated circuits, we will use equivalent transistor circuits for instructional purposes.

Delay Multivibrators. These are monostable multivibrators whose delay is determined by the duration of the unstable state. Fig. 10. is a typical example. In the stable state, Q1 conducts heavily because its base resistor, R5, connects to the positive supply. The base of Q2, on the other hand, is returned to the voltage divider consisting of R1, R2, and R3. Under steady-state conditions the voltage developed across the common emitter resistor R6 is higher than the voltage developed at the junction of R2 and R3 and Q2 is held in cutoff. In this state the left side of C1 is at the supply voltage (no voltage drop across R4) and the right side is at the relatively low base voltage of Q1. Thus, C1 waits with a charge that is a substantial fraction of the supply voltage, positive on the left, negative on the right.

The unstable state is triggered by a negative pulse applied to the collector of Q2 and via C1 to the base of Q1. If Q1 is driven to cutoff its

collector voltage rises towards the supply and the base of Q2 rises above the emitter voltage. Q2 saturates bringing its collector down to the emitter voltage. C1 must then dump its charge through R5, and Q1 is held in cutoff until C1 has sufficiently discharged to allow the base of Q1 to rise above the emitter level. The MV remains in the unstable state, with Q1 cut off and Q2 saturated, until C1 dumps its charge.

The duration of the unstable state is determined primarily by the RC time constant of C1 and R5. R5 is made adjustable where the delay is to be variable, as in the PG phase and REC LOCK phase MVs shown earlier.

Control of the unstable interval can also be achieved by varying the voltage to which the top of R5 is returned. If this voltage is made less positive, for example, Q1 will remain in cutoff longer and the unstable interval will lengthen. This electronic control of the off interval, equivalent to adjusting the value of R5, is put to use in many servo systems.

Note that the output waveform is in the form of a positive pulse whose duration is determined by the time that Q1 is cut off. Thus the MMV can be used as a variable-width pulse generator. However if the circuit this MMV drives is also triggered by the negative-going transition, the MMV introduces a timing delay equal to the duration of the unstable state.

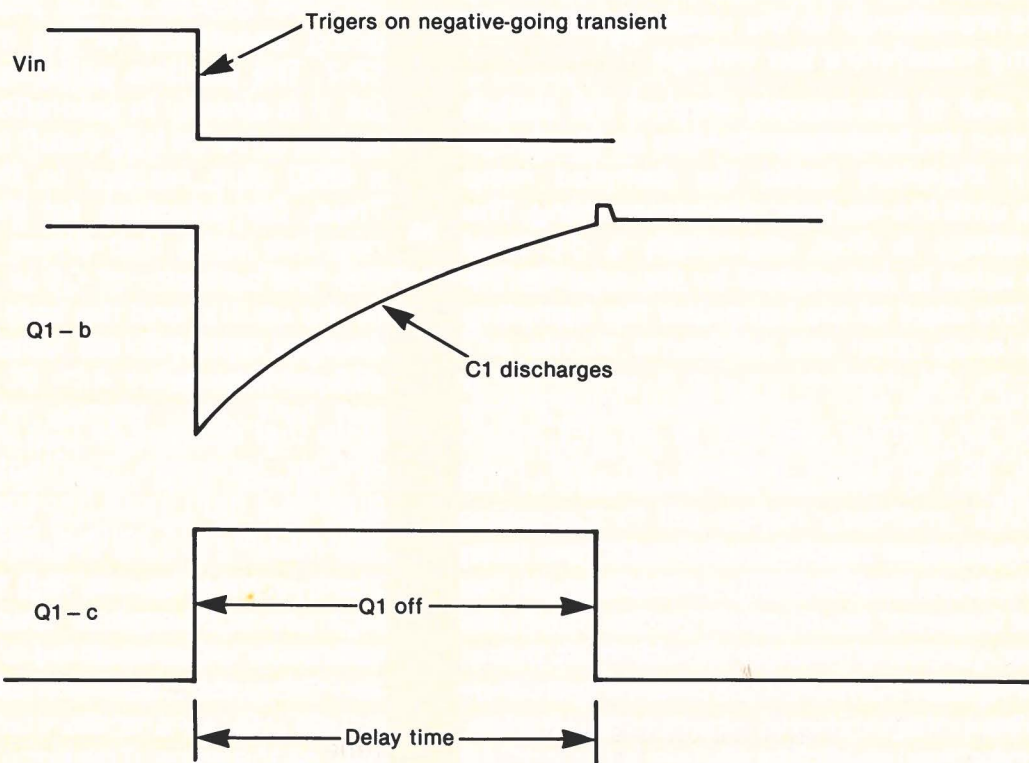
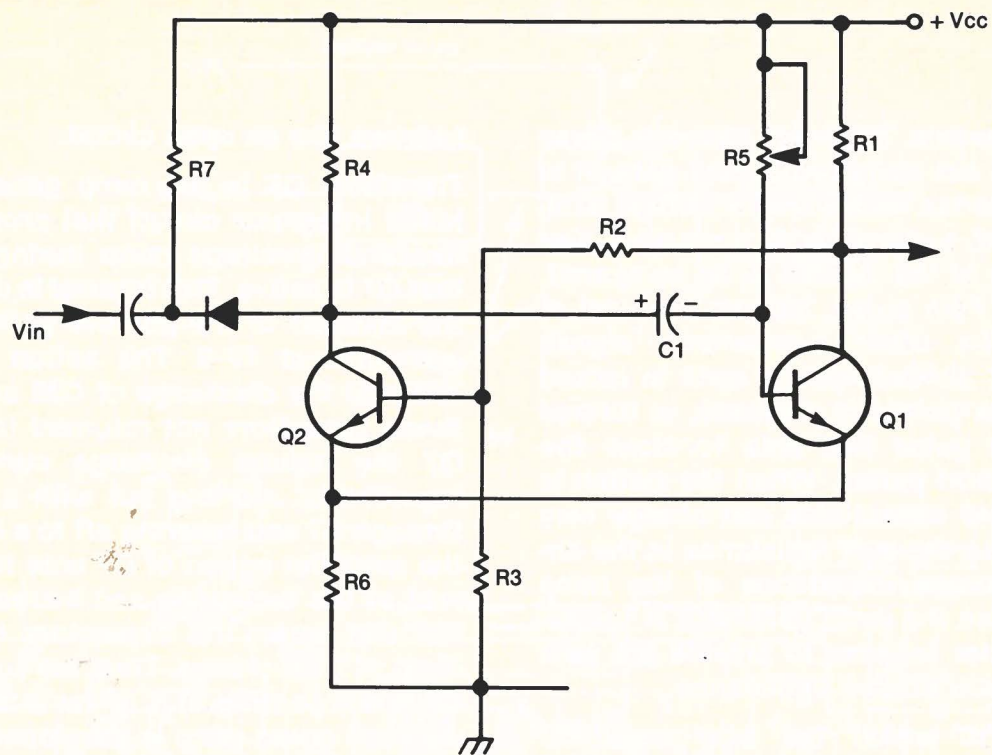


Fig. 10. Monostable (one-shot) multivibrator.

Phase Comparators. The most common phase comparator is the sample-and-hold gate. It is essentially a series switch with a voltage ramp at its input and a capacitor at its output. See Fig. 11(a). One of the signals to be compared, usually the 30 PGA pulse, triggers the start of the ramp. The other comparison signal, separated and divided vertical sync in record or control-track pulses in playback, is formed into a narrow pulse that acts to close the switch for a short period. When the switch is closed the hold capacitor can charge very quickly because the only resistance in the circuit is the source impedance of the ramp generator. Often the ramp generator is followed by an emitter follower to provide the gate circuit with a low source impedance.

The voltage to which the hold capacitor charges is the value of the ramp at the time that the switch is closed. If the switch in Fig. 11(a) closes late, the voltage at the top of the ramp is transferred to the capacitor. An early sampling transfers a low voltage.

At the end of the sample interval the switch opens and the hold capacitor has no discharge path. It therefore holds the sampled ramp voltage until the next sample comes along. The hold voltage is thus essentially a d-c level whose value is determined by the relative timing of the start of the ramp and the sampling pulse.

A buffer stage with a high input impedance, such as an emitter follower or an FET stage follows to minimize loading on the hold capacitor.

Fig. 11(b) shows a sample and hold gate from an early U-matic (VP-1200). In this circuit the start of the ramp is triggered by the CTL pulse and the gate is closed by the 30 PGA pulse. Transistor Q8 serves as the series switch or gate. The voltage ramp is applied at its collector and the hold capacitor, C28, is in its emitter circuit. Under steady-state conditions the gate driver, Q9, is saturated, holding the base of Q8 at ground potential. Under these conditions Q8

behaves like an open circuit.

Transistor Q7 is the ramp generator. It is a Miller Integrator circuit that provides a linear descending-voltage ramp during the interval that Q7 is active. This interval is determined by the duration of the positive going part of the waveform at TP-8. The action of Q7 is to linearize the discharge of C26 and C51. Were these capacitors not returned to the base of Q7 the natural discharge curve would be logarithmic, starting out with a high current through Q7 and tapering off to a low value. But the amplifier action of Q7 acts to oppose current at the beginning and increase current at the end when the capacitors have dumped most of their charge. Thus the current through Q7 tends to drop at a linear rate and a linear negative going ramp is developed.

The rectangular wave applied to the gate driver Q9 is differentiated by C30 to form positive and negative spikes at the positive and negative going transitions of the input wave seen at TP-7. The positive going spikes do not affect Q9. It is already in saturation. But the negative spikes drive Q9 into cutoff leaving Q8 with only a 6800 ohm resistor to the positive supply. Thus, Q8 saturates for the duration of the negative spike that drives Q9. During saturation the collector of Q9 is effectively shorted to the emitter and the hold capacitor C28. C28 charges rapidly to the ramp voltage during the sample interval.

Note that the load on C28 is a pair of cascaded emitter followers (Darlington circuit). These provide a high input impedance to prevent the loss of the hold voltage between samples.

The system shown in Fig. 11(b) is from a braking servo. Consider the situation if the reference video head were late in arrival. The 30 PGA pulse would then be late compared to the CTL pulse and the start of the downward part of the ramp. The ramp would be sampled nearer the bottom and the hold voltage, and hence brake current, would drop allowing the scanner servo to advance in phase.

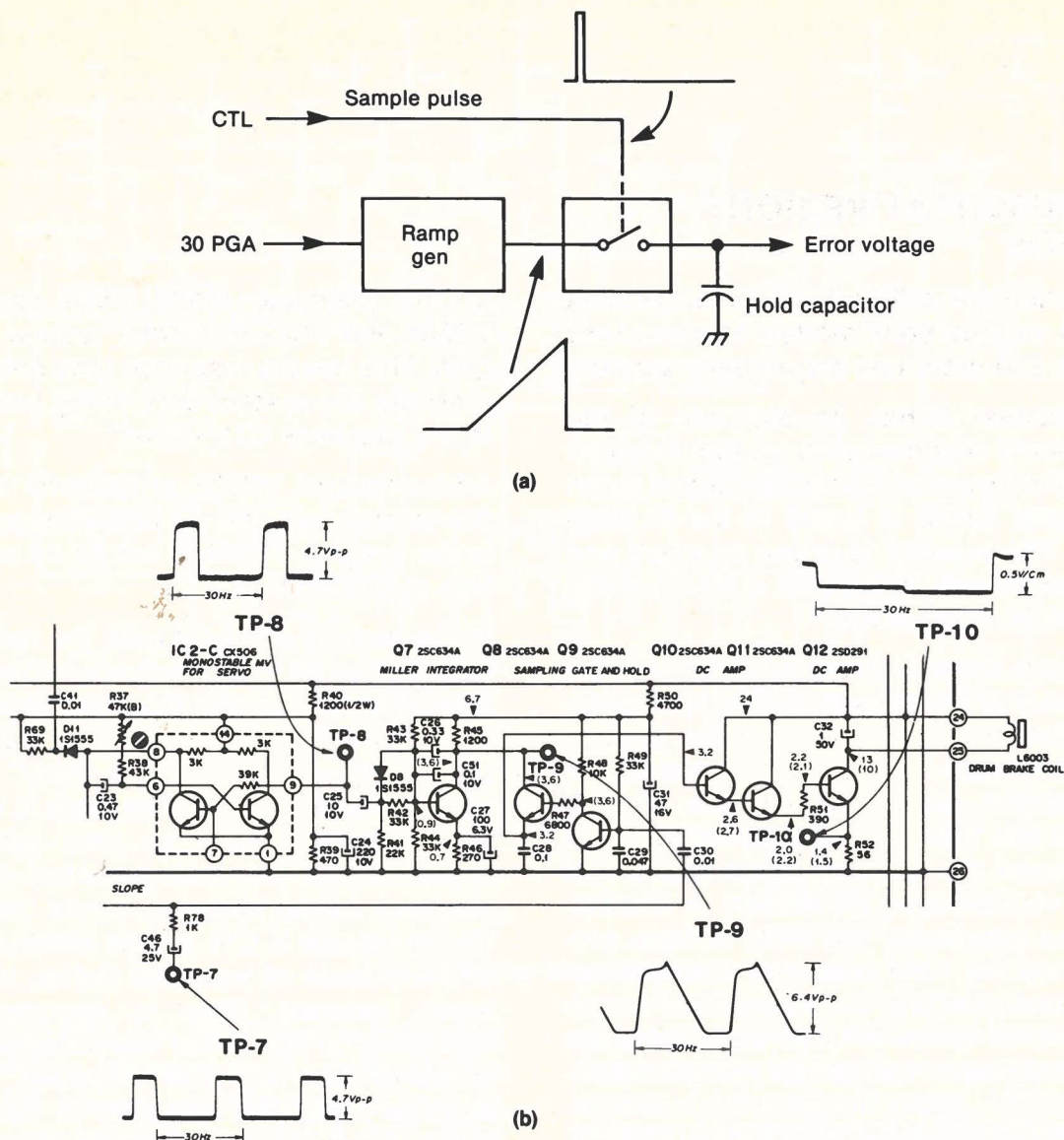


Fig. 11. Sample-and-hold gates.

It was mentioned earlier that the ramp is usually triggered by the 30 PGA pulse and the CTL (or sync) drives the sample gate. That has come to be common practice in later machines, but the situation was reversed in early machines. The advantage of the later system is that the ramp is always present and is not affected by the loss of control track pulses due to dropout or tape-edge damage. The loss of a sample pulse does not affect the system greatly as the hold capacitor continues to hold most of the voltage from the earlier sample. In the old system, however, loss of a CTL pulse kills the ramp and the sample results in a large change in hold voltage with consequent interruption of servo action.

The circuit preceding the ramp generator is worth noting. It is a monostable MV whose off time is determined by R37, R38 and C23. In this case the MMV is not used for delay purposes but to determine the duration of the positive going part of the output waveform, since this positive going interval determines the active period, or the slope of the ramp. Hence R37 is labelled "slope." Ramp slope is one of the factors that determine servo gain. A steep slope yields a greater change in error voltage for the given timing error. In the alignment procedure, R37 is set for a slope of 0.5V per millisecond. A steeper slope could make the circuit unstable, prone to overshoot or even oscillation.

3. REPRESENTATIVE SONY SERVOS

In this section we will look at servo systems taken from various Sony models to show how techniques and practices are actually applied.

Braking Scanner Servo. An example of the straightforward scanner servo system in which tape speed is driven at a constant speed by an a-c hysteresis motor is found in the SL-6200 (Betamax). The scanner is driven by a belt and pulley arrangement to provide a free-running speed of 30.34 to 30.43 rps.

Fig. 12. shows the overall servo circuit. As you can see, most of the active circuitry is contained in two dedicated integrated circuits. We can begin at the heart of the servo system, the sample-and-hold gate. It is between pins 23 and 24 of IC 502. Here the timing comparison is made between the 30 PGA pulse and either separated vertical sync (in record) or control-track pulses (playback). The error voltage, produced across the hold capacitor C521, is applied to a non-inverting d-c operational amplifier and emitter follower Q502 which has the brake field winding in its emitter return to B+.

The anti-hunt circuit is in the form of a negative feedback loop to the inverting input of the op amp. In the record mode, gain is increased by adding more resistance to the negative feedback path and turning it into a high-pass filter by the insertion of C522. This tends to reduce loop gain at the frequency where the servo would tend to oscillate. VR 506 is adjusted by observing the time taken for the servo to lock up and any tendency to overshoot. The scope observation is made in the record mode by observing the video head switching signal at TP-501 and triggering the scope from separated vertical sync at TP-504. A disturbance is introduced by tapping the a-c motor fan and watching the servo recover. At full recovery the head switching waveform becomes stationary with respect to vertical sync. VR506 is set to allow one overshoot.

In the playback mode R524 shunts R525, VR506 and C522 to further reduce servo loop gain. This lowers response time somewhat but prevents the system from trying to follow jitter in the playback CTL signal.

A bias control, VR505, at the inverting input to the op amp sets the d-c operating point for the brake system. VR505 is set for an average of 5 Vdc at IC502 pin 2.

In the sample-and-hold gate the ramp is derived from the 30 PGA feedback pulse. The ramp generator is a simple RC integrator, R517 and C518, which is driven by a square wave developed by a MMV "duty delay" set to provide a 50% duty cycle. The ramp is quite steep in the record mode so loop gain is high, response fast and timing control tight. In the playback mode, however, where the source of timing signals is CTL pulses which are subject to the effects of wow and flutter, loop gain is again reduced. This is accomplished by switching in the extra capacitance C519. Increasing the RC time constant of the integrator slows the rise time of the ramp and makes it less steep. The falling side (negative going) of the waveform is used for sampling purposes.

Tracing the sampling ramp back to its source we find the duty delay MMV, which does not introduce a delay at all but is set to produce a square wave with a 50% duty cycle. The duty delay MMV is triggered by a lock PG delay MMV. This MMV is triggered directly from the 30 PGA amplifier. Its delay, determined by the external RC components R505 and C507, introduces a fixed delay that compensates for the adjustable delay introduced into the sync/CTL processing chain. Both fixed and variable delays place the ramp and sampling pulse at the correct relative timing when the position of the reference video head is correct.

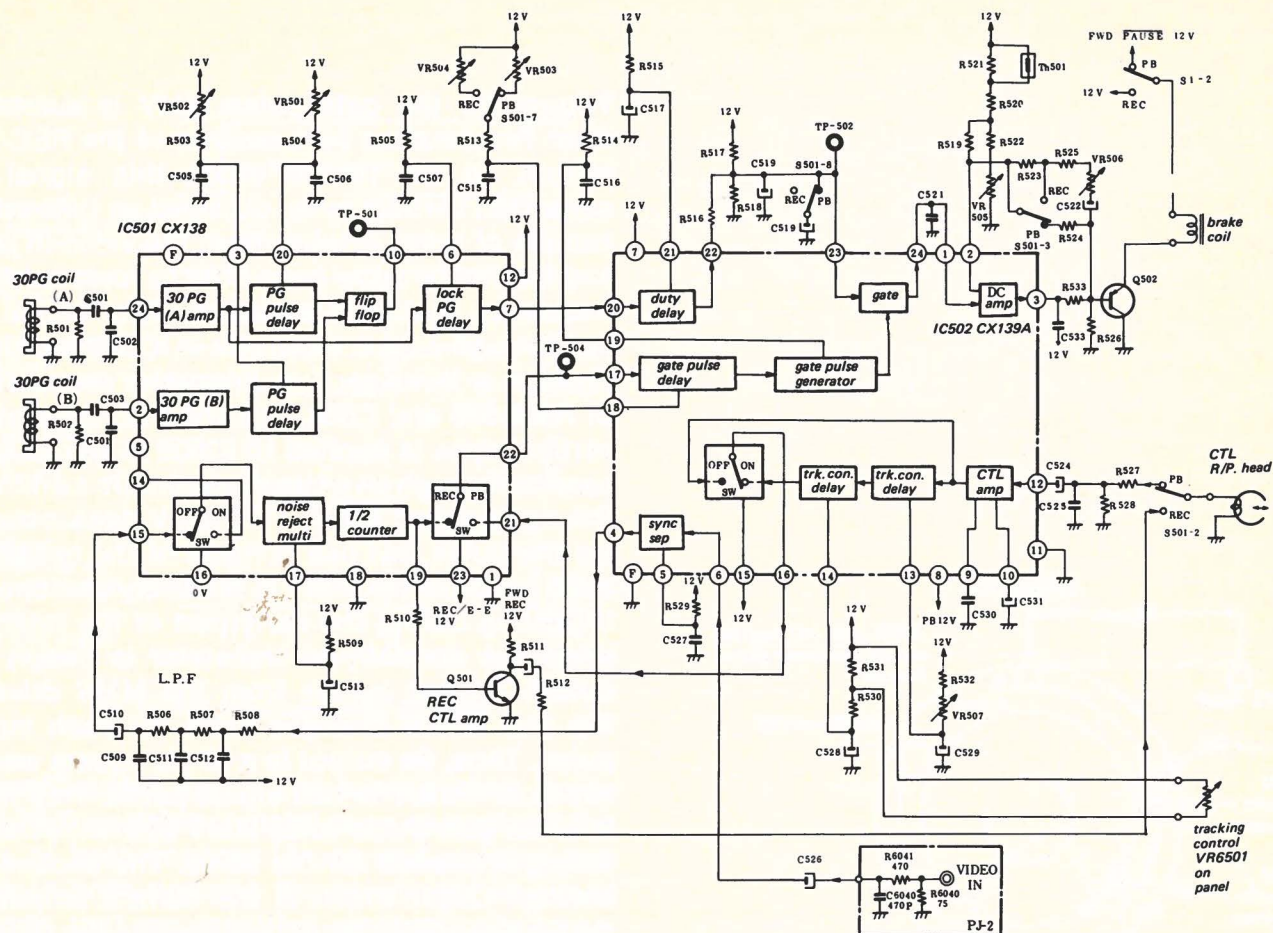


Fig. 12. Braking servo (SL-6200).

Pulse coils 30 PGA and 30 PGB drive individual pulse amplifiers followed by PG delay MMVs. Here the PG pulses are trimmed in time to place the head-switching point 7 horizontal lines ahead of vertical sync. Potentiometers VR501 and VR502 are adjusted for this purpose. They are set during playback of the factory alignment tape wherein the position of vertical sync from the start of the video track is precisely controlled. The delayed outputs of both PG delay MMVs toggle a flip-flop alternately to provide the square wave observed at TP-501. This signal is routed to the playback preamps for video-head switching.

Now let's follow the route of the ramp-sampling pulses. A gate-pulse generator supplies the pulses that close the gate that connects the ramp to the hold capacitor. This MMV does not introduce a delay but provides narrow sampling pulses when triggered by the gate-pulse delay MMV. The latter introduces an

adjustable delay that can be trimmed independently for both record and playback modes. In the record mode, VR504 is set by comparing the input video signal with the head switching signal using a dual-trace scope. Correct adjustment places the head switching transition 7 lines ahead of vertical sync. This adjustment normally follows the adjustment of VR501 and VR502. Hence, switching point is set using the alignment tape as a reference; then record lock phase is set to match record vertical sync to the same timing reference. VR503, PB lock phase, is set by playing back the machine's own recording and adjusting for a specified delay between the head-switching signal (TP-501) and the CTL signal (the start of triggering at IC502 pin 13). A slightly longer delay is needed in playback because the playback sampling ramp is not as steep and the extra delay places the sample pulse in the center of the ramp.

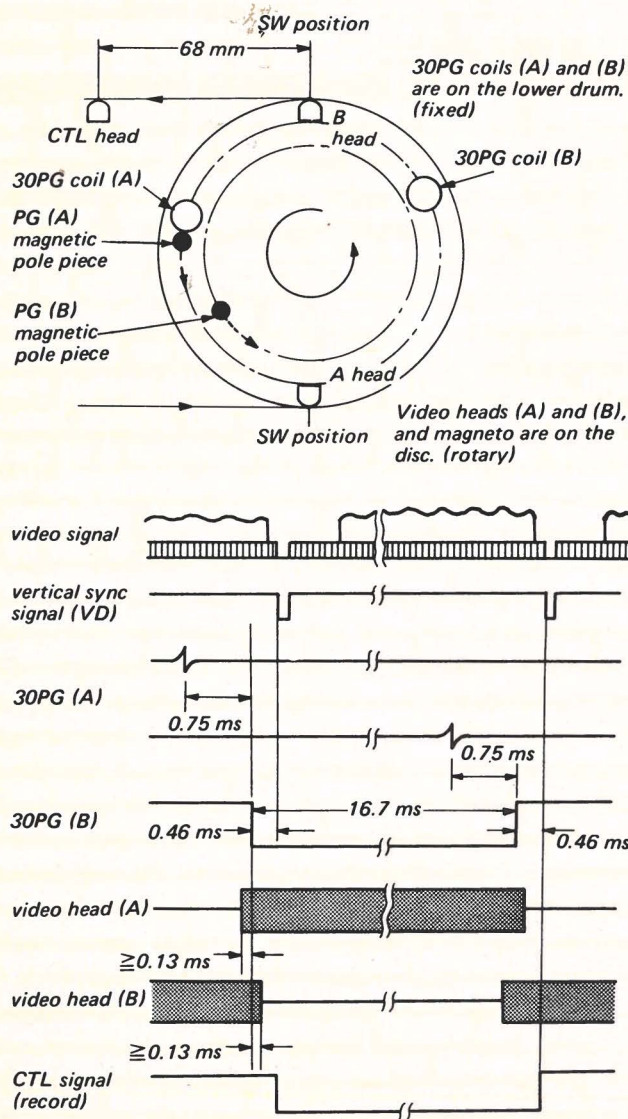


Fig. 13. PGA waveforms with respect to video and r-f envelope (SL-6200).

Trigger for the gate pulse MMV is selected from two sources by a section of the REC-PB switch. In the record mode this signal is separated vertical sync, obtained as follows. A sample of video is taken from the video-in jack and filtered by a low-pass filter to remove high-frequency (color) information. This signal is fed through a sync separator in IC502 and then through a three-section integrator consisting of R506-508 and C509, 511 and 512. Separated vertical sync is applied to IC502 at pin 15 and passes through an unused electronic switch to the noise-reject MMV. This MMV does not delay the pulse, but use is made of the unstable state because the MMV is relatively immune to triggering during the early part of the interval when the normally-on transistor is deeply in cutoff. Trigger pulses from the MMV drive a flip flop which changes state for each input pulse. Thus, its output is a 30 Hz square wave, which is routed to two signal paths. This first is to the gate pulse delay MMV where it acts as timing reference for the servo. The second is through Q501, which is the current amplifier that drives the control-track head in the record mode.

In playback, control-track signals are routed through a section of the REC-PB switch to the CTL amplifier in IC502. Following amplification, the signal is applied to two cascaded MMVs. The first has a technician-adjustment for delay time; the second contains the front-panel TRACKING control. VR507 is set in playback with the TRACKING control set to its detented mid-range setting. The positive going transition at IC502 pin 16 is then made to line up in time with the start of the wave form at pin 13. The latter coincides with the input CTL pulse. In this way a delay time equal to one frame, or the space between control track signals, is obtained. Note that IC502 has provision for electronically bypassing the tracking delay MMVs. This provision is not used in the SL-6200 and a constant 12 volts is applied to pin 15 to keep the switch in the position shown.

Figs. 13. and 14. show key waveforms in the SL-6200 servo.

30PG (A)

lock PG
delay M.M.V. (1)

duty 50%
M.M.V. (4)

integrating
circuit
(REC mode)

gate pulse
generates
(in IC)

gate signal
input
flip-flop (2)
or M.M.V. (9)

VD
(REC mode)

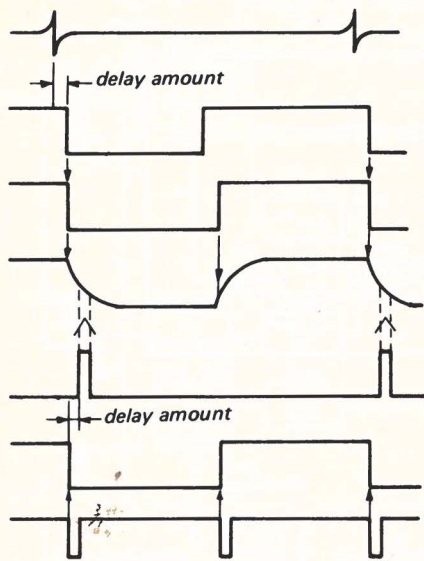


Fig. 14. Key servo waveforms (SL-6200).

Drum/Capstan Servo. The servo system in the VO-3800 portable U-matic is an example of the use of both scanner (drum) and capstan servos. In both systems the servos act as speed servos that are modified electronically to accomplish the desired phase relations. Let's examine the scanner servo first.

The scanner contains three PG coils and a single iron vane cuts the field of each. Layout of the stationary pulse coils and the moving vane is as shown in Fig. 15. Pulse coils PG 1 and PG 2 drive the speed controller, as shown at the top of Fig. 16. In this system the time interval between the generation of PG 1 and PG 2 is compared against the fixed time interval provided by a monostable MV. As shown in the waveform sketches of Fig. 16, the signal from PG 1 is amplified and applied to a MMV (one-shot) which inserts an adjustable delay. At the end of this delay period a sampling ramp begins. This ramp is sampled by an amplified pulse from PG 2. If the scanner should slow down, the time interval between PG 1 and PG 2 lengthens. The sample pulse then rides higher on the ramp and a higher voltage is stored on the hold capacitor. This raises motor armature current to correct the speed. The fixed delay introduced by the MMV in the PG 1 chain determines free-running speed.

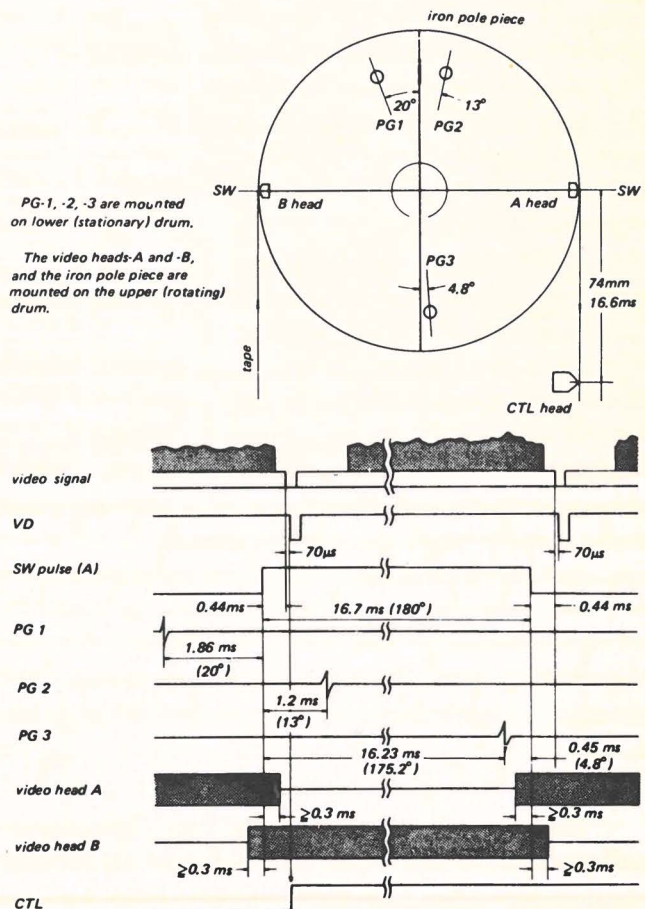


Fig. 15. Pulse-coil layout and servo timing for the VO-3800 scanner.

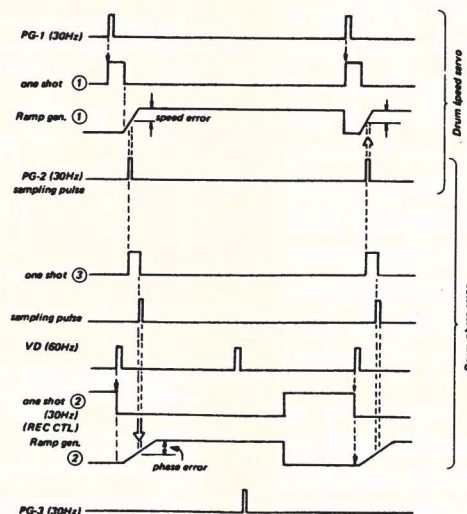
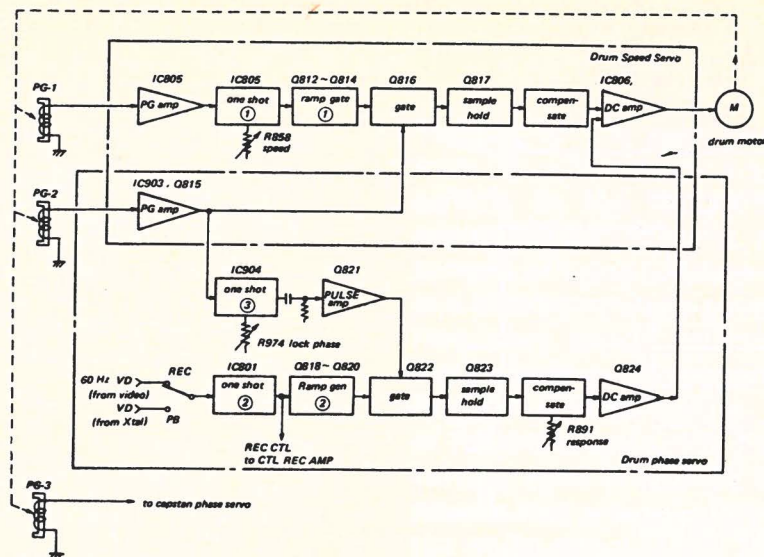


Fig. 16. Scanner servo (VO-3800).

Phase correction of the speed servo is achieved by the lower group of blocks in the block diagram of Fig. 16. Here the phase comparator compares the scanner feedback pulse from PG 2 with a field-rate pulse in the record mode. This reference is derived from separated vertical sync in the TV record mode or from a field rate pulse developed by an internal sync generator in the camera-record mode. The sync generator pulse is always used in playback.

Vertical drive triggers a MMV which develops the ramp. The ramp is sampled by a pulse from PG 2 that has undergone an adjustable delay in MMV IC904. Control of this delay is the servo

lock phase adjustment. It is set in the record mode for the required 6.5 H lead for video head switching with respect to vertical sync. The B head is the reference head in this case. PG 1 is used to develop the head switching signal. It generates its pulse 20° before the B head crosses the head switching point labelled SW in Fig. 15.

Following the phase sample-and-hold gate a variable lag network adjusts servo response time. The d-c error voltage so developed is routed to the same d-c amplifier that is driven from the speed servo. Hence the phase error acts to speed up or slow down the scanner motor until the correct phase relation is found.

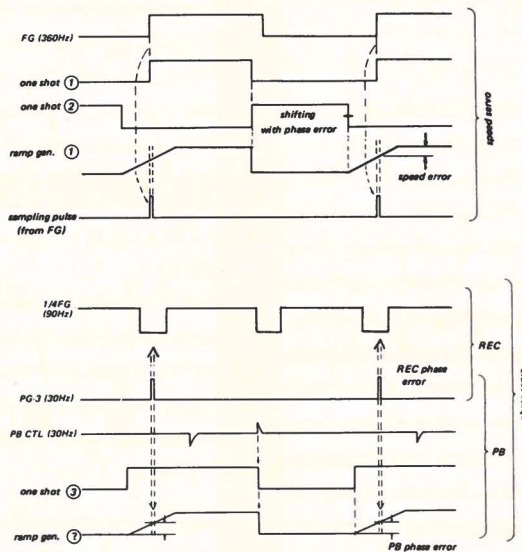
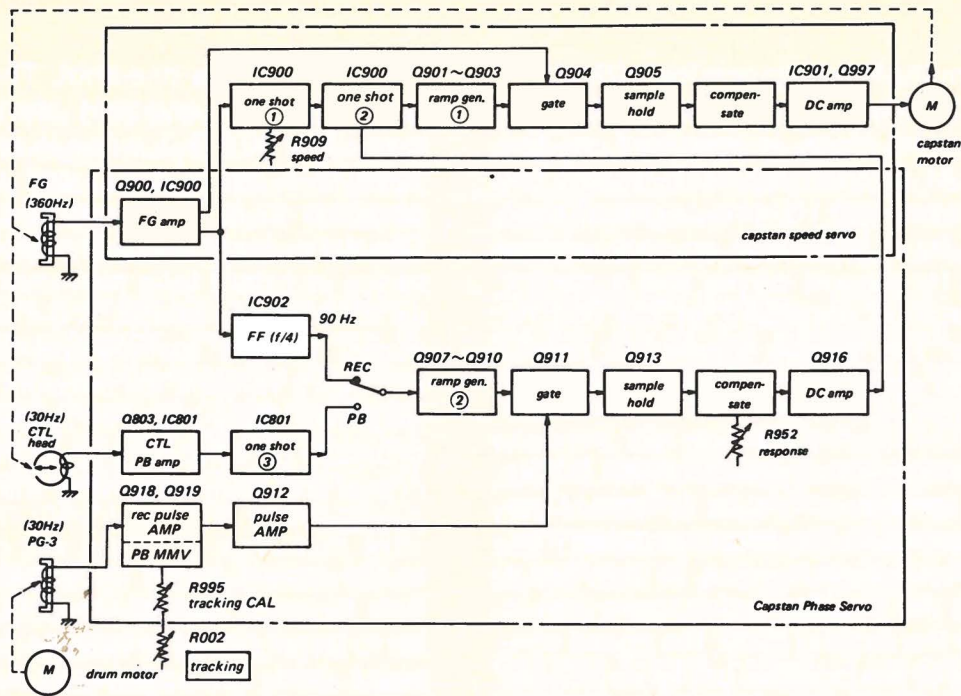


Fig. 17. Capstan servo system (VO-3800).

Scanner speed/phase servos based on the principle shown in Fig. 16. are used in many VTRs. In later models the number of PG coils has been raised from 2 to 6 so that more samples per revolution are taken of scanner speed. This helps to improve speed stability and minimizes the gyro effect on the rotating mass of the upper drum when the portable VTR is subject to abrupt acceleration. In other machines the role of the PG coils is provided by an a-c tone generator. But the principle is the same. In

each case the period of the signal produced by the scanner is compared with the period of a MMV.

The capstan servo of the VO-3800 is an example of a speed servo using a tone, or frequency generator (FG) to provide the speed analog. Refer to Fig. 17. Here again the top row of blocks is the speed servo; the bottom row provides phase correction.

The Fg is a multiple a-c generator with a PM field that rotates inside a stationary armature. The rotating field piece is mounted on the motor shaft. At the correct tape speed the generator delivers 360 Hz sine waves. These are amplified by a two-stage op amp whose output is 360 Hz square waves and a narrow pulse, for sampling purposes, at the 360 Hz repetition rate. The square waves are fed to both the speed and phase servos to develop the sampling ramps.

In the speed servo, two cascaded-delay MMVs generate the sample ramps as follows. One-shot #1 is triggered by the negative going transition of the input square wave. It provides a delay equal to the positive going wave that is determined by the setting R909, the speed control. At the end of the positive going-wave, one-shot #2 is triggered by the negative going transition of the input square wave. The ramp begins at the negative-going transition at the output of one-shot 2. If we consider the two delays to be fixed in time, you can see that this speed servo works just like the scanner servo. If speed tends to drop below 360 Hz the period of the wave stretches out and the sample pulse will occur higher on the ramp. The resulting increase in hold voltage is amplified and applied to the motor as an increase in armature current.

But the delay inserted by one-shot 2 is variable. It is voltage-controlled by the d-c output of the phase sample-and-hold gate. This voltage control was explained earlier for monostable multivibrators. It is the electrical equivalent, in this case, of adjusting R909.

Phase control acts to advance tape or slow it down until pre-recorded video tracks are in position around the scanner at the time that the A head is starting its swipe. To accomplish this in playback, the timing of control-track signals is compared with the PG 3 pulse produced by the scanner. Look back at Fig. 15. and you will note that the iron vane will sweep over PG 3 4.8° before the A head reaches the head switching point on the scanner.

To make the phase comparison in playback, output from the control-track head is amplified

and applied to a one-shot. The positive going output of this one-shot starts the sampling ramp. The 30 PG 3 pulse is amplified and applied to a delay MMV, and then to a pulse amplifier to develop narrow sampling pulses. The delay inserted by the MMV serves to advance or retard tape movement and so serves as the tracking control. A d-c error voltage produced by the sample-and-hold gate is fed through a variable lag network to control servo response. R952 is set by tapping the top of the capstan to introduce a momentary loss of phase and then observing the recovery of the system.

In the record mode the capstan servo serves only to move tape at the right speed. There is no external phase reference. Hence the 30 PG pulse from the scanner is simply compared with a divided-down sample from the frequency generator. FG output is first divided by four by two cascaded flip flops. The resulting 90 Hz signal is applied to the ramp generator. However, the 30 Hz sample pulse is present for only one of the three ramps so generated, and the sampling takes place at the 30 Hz rate.

4. APPROACH TO TROUBLESHOOTING

Servo troubleshooting starts with recognition of the visual symptoms of failure. Speed errors of the scanner or capstan are the most frequent and the symptoms depend upon whether failure is in the playback or record mode and the type of servo system.

Braking Servos. These systems present unique symptoms because complete loss of servo action does not result in a large change in scanner speed. An open brake coil, for example, allows the scanner to increase to the normal free-running speed of about 30.4 rps. Not a very big change, and the symptoms are sometimes confusing. In playback the scanner turns at nearly the right speed, but is not phase controlled by control track pulses. As tape is pulled past the scanner, the heads will run down the tracks at times and be off into the guard bands at other times. During the times that the heads hit the center of the tracks the picture looks normal, even the head switching point is

in the right place. The clue is the band of noise that runs down through the picture when the heads are off the tracks. This noise band appears with a regular rhythm (about 5 times in 10 seconds) and that's the clue to servo failure.

If the servo is not functioning in the record mode but o.k. in playback, the symptom is somewhat different. In this case the machine will playback tapes made on other machines but will not playback its own. Of course tapes made on the machine in question will also not playback on other machines. The visual symptom is similar to the playback symptom with one important difference. The switching point appears to move through the picture. The reason is that the location of vertical sync is no longer tied down to the beginning of the track but appears at random locations. In playback the head switching point is still determined by the scanner PG coils and happens at a particular time with respect to head movement. The monitor continues to lock up vertically on the playback vertical sync pulse so the switching point appears to move.

What would cause loss of servo action in record only? The servo reference in the record mode is separated vertical sync. Failure in the signal chain between the source of video and the section of the REC-PB switch that selects either separated sync or CTL pulses is the prime suspect in this fault.

If the free-running speed falls below 29.97 rps a braking servo naturally cannot function and the noise bar will move down through the picture. This might result in a scanner speed that is very close to the normal speed. In that case the rate at which the noise bar appears in the picture might be very slow indeed. The drive belt should be inspected for scoring, wear or excessive length if low speed or erratic servo action is indicated.

Speed can be checked using a frequency counter capable of measuring *period*. There is not sufficient resolution when frequency is measured. A useful signal to drive the counter is the head-switching square wave. To find the correct period, take the inverse of the correct free-running speed. For example $1/30.34 \text{ rps} =$

32.96 ms. Free-running speed should be measured with the brake coil disconnected. If it is right under this condition, but drops substantially when the brake is connected, suspect a d-c fault in the servo output stages.

Speed-Phase Servos. Scanner servos that employ d-c or a-c servomotors can develop faults that produce relatively large speed errors. Loss of the sample and hold output, for example, can result in a major shift in armature current. The overriding symptom in this case is very similar to loss of horizontal sync in a TV set. The picture is broken into many horizontal bands due to a large change in both vertical and horizontal sync rates.

Captstan Servos. Failure of the capstan servo in playback produces the same symptoms as described for braking servo: the band of noise running through the picture. In addition, tape speed errors may be detected easily in audio reproduction as a change in pitch or wow.

Start at the Phase Comparator. The comparator is a good place to start in localizing troubles in the servo system. It must have a ramp and sampling pulse. Loss of either points the way to further investigation. If both are present but moving with respect to one another, then the output of the comparator is not doing its job. In the case of an open brake coil, for example, both the ramp and sampling pulse will be observed at the inputs to the sample and hold gates. However, they will be moving with respect to one another. In addition, a rhythmic rise and fall in hold-capacitor voltage will be seen.

Visual Tips. Most service shops employ fluorescent lighting. This turns out to be a bonus in scanner servo troubleshooting due to stroboscopic effects. If you observe the rotating upper drum with fluorescent light you will notice a blurred pattern that appears to rotate very slowly; it is stationary if a monochrome recording at the 60 Hz field rate has been recorded. You will spot it easily if you turn the machine on and off. The blur will rotate quickly and then stabilize as the servo locks up. This provides a very quick and easy check for servo lock up and is a real time saver.

Sony
Basic Video Recording Course
Booklet 6
Glossary of Servo Systems

Braking Principle, Magnetic—A servo speed control method that uses electro-magnetic force to variably slow down or speed up the driven shaft.

Capstan Servo—A self-correcting system which controls videotape timing by varying the tape speed past the capstan.

D-C error voltage—A comparator output signal which is proportional in magnitude and polarity to the operational error in a feedback control system.

Delay Multivibrator—A monostable multivibrator which outputs a pulse a predetermined time after it is triggered (by an input pulse).

Duty Cycle—The amount of time a device operates, as opposed to its idle time.

Frequency Generator (FG)—An a-c generator coupled to the scanner with which drum speed is measured.

Lock-Phase Delay—A timing pulse circuit which is used to delay the PGA pulse in order to make it coincident with the on-tape vertical sync.

Miller Integrator—A type of amplifier circuit which reacts to a logarithmic input in an antilogarithmic manner, to generate a linear response.

Monostable Multivibrator—A circuit having only one stable output state, which can be triggered to change the state for a predetermined interval, after which it returns to the original state.

PGA, 30—A servo timing pulse generated electromagnetically by rotation of the head drum, used as feedback in the scanner servo.

PGA Phase—The amount of delay inserted by the 30 PGA and PGB multivibrators, usually controlled by a potentiometer.

PGB, 30—A second servo timing pulse generated by a coil/magnetic pole arrangement near the head drum which is used for timing video head switching.

Phase Comparator, VTR—A circuit for comparing the phase (timing) of two events and producing a feedback correction voltage.

Pulse Generator—An electromagnetic device for generating a controlled series of electrical pulses, normally used to monitor rotation speed.

Reference Video Head—One of the two heads in a helical scanner, chosen as a frame of reference.

Sample-and-Hold Gate, (Phase Comparator)—An electronic circuit which uses the phase of one input to control a gating switch and holding capacitor, and the other to initiate a voltage ramp. If the switch is closed for a short time (the phase difference), the capacitor will store a quantity of charge representative of the phase difference.

Scanner Servo—A feedback control mechanism which adjusts video head timing by controlling head drum speed.

Timing (phase) Error, Scanner—The deviation from the correct rotational position of the head drum, in reference to the CTL pulse (off-tape or video sync).

Tracking—The ability of a video head and tape drive to scan a pre-recorded track.

Tracking Control—A variable delay multivibrator inserted into the control-track pulse playback signal path, for tracking adjustment.

SONY
BASIC VIDEO RECORDING COURSE
SELF-TEST NO. 6
SERVO SYSTEMS

1. In the phase comparator of a scanner servo operated in the playback mode, the 30 PG feedback pulse is compared with: (a) separated vertical sync; (b) the head switching signal; (c) control-track pulses; (d) frequency generator output.
2. A typical free-running speed for a braking servo is: (a) 30.4 rps; (b) 30 rps; (c) 60 rps; (d) 29.97 rps.
3. 30 PG pulse coils in the scanner provide timing feedback for the servo and act as the source of signals for: (a) video head switching; (b) color crosstalk cancellation; (c) power supply switching; (d) control-track recording.
4. An error in the position of the audio/CTL head stack along the tape path results in: (a) loss of servo; (b) head switching error; (c) continuous mistracking; (d) rhythmic mistracking.
5. The 30 PGA pulse coil is usually placed so that the pulse is generated: (a) when the A video head crosses the switching point; (b) before the A video head crosses the switching point; (c) after the A video head crosses the switching point; (d) just before the B head crosses the switching point.
6. The source of signal used to adjust the head switching point is: (a) an NTSC color bar generator; (b) off-air broadcast signal; (c) the factory alignment tape; (d) any prerecorded tape.
7. The delay introduced by the tracking MMVs when the TRACKING control is set to mid range is: (a) 1/60th of a second; (b) 1/29.97 of a second; (c) 16.67 mS; (d) 63.5 μ S.
8. Shortening the delay of the tracking MMVs is equivalent to: (a) moving the CTL head further from the scanner; (b) moving the CTL head closer to the scanner; (c) moving the 30 PG coil counterclockwise; (d) increasing capstan speed.
9. The operator sets the TRACKING control: (a) in the record mode; (b) in the playback mode for best servo lock; (c) in the playback mode for correct head switching; (d) in the playback mode for best picture S/N.
10. Editing machines must employ: (a) scanner servos only; (b) capstan servos only; (c) capstan and scanner servos; (d) scanner servos with multiple-speed capstan motors.

11. In the insert editing mode the capstan servo system operates: (a) in the record mode; (b) in the playback mode; (c) as a straight speed controller; (d) without phase correction.
12. If C1 in Fig. 10. is made larger the: (a) on interval for Q1 gets longer; (b) the off interval for Q1 gets shorter; (c) the off interval for Q1 gets longer; (d) free running frequency drops.
13. The duration of the unstable state in the circuit shown in Fig. 10. can be reduced by: (a) making C1 larger; (b) making R5 larger; (c) making R6 larger; (d) returning R5 to a higher d-c voltage source.
14. In most late model VTRs the start of the sampling ramp in the drum servo is triggered from a pulse obtained from: (a) the CTL head; (b) separated vertical sync; (c) the 30 PGA pulse; (d) 30 PGB pulse.
15. Increasing the steepness of the sampling ramp results in: (a) higher loop gain; (b) slow response time; (c) mistracking; (d) an advance in the head-switching point.
16. The circuit following the hold capacitor is usually characterized by: (a) phase inversion; (b) high input impedance; (c) low input impedance; (d) unity gain.
17. A scanner servo that locks in the record mode but does not lock in playback probably has a fault in the circuits that process the: (a) CTL signal; (b) 30 PGA signal; (c) 30 PGB signal; (d) phase comparator error-voltage output.
18. In the circuit of Fig. 12. a short in C509 would result in: (a) no vertical sync; (b) loss of servo in both playback and record modes; (c) loss of servo in the playback mode; (d) loss of servo in the record mode.
19. In the circuit of Fig. 12. a short to ground at IC501 pin 7 would result in: (a) a decrease in scanner speed; (b) loss of servo in both record and playback modes; (c) loss of servo in the playback mode; (d) loss of servo in the record mode.
20. In the circuit of Fig. 12. a misadjusted VR501 will result in: (a) mistracking; (b) head switching at the wrong place in record only; (c) head switching at the wrong place in playback; (d) slow servo response following disturbances to scanner speed.

Answers:

- | | | | |
|--------|---------|---------|---------|
| 1. (c) | 6. (c) | 11. (b) | 16. (b) |
| 2. (a) | 7. (b) | 12. (c) | 17. (a) |
| 3. (a) | 8. (b) | 13. (d) | 18. (d) |
| 4. (c) | 9. (d) | 14. (c) | 19. (b) |
| 5. (b) | 10. (c) | 15. (a) | 20. (c) |



277-
89

3



SONY®

Video Products Company

Published by

VIDEO TECHNICAL INFORMATION

700 WEST ARTESIA BLVD., COMPTON, CA 90220

© 1979